

Final

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This report summarizes relevant scientific accomplishments under the NASA grant:

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#NAGW-1571

to the University of Texas at Dallas for aeronomic research on the topic:

"Atomic Hydrogen and Nitrogen Distributions from Atmosphere Explorer Measurements"

by E. L. Breig and others.

The original proposal to NASA covered three years, but the program was funded at a reduced rate for only two years. We remain highly appreciative of the opportunity, during this period of limited resources, to continue our research efforts in this field.

As a consequence of the above constraints, we were selective as to our approach to research activities, and devoted primary attention to two investigations concerning the global behavior of atomic hydrogen in the Earth's upper atmosphere. We derive the thermospheric concentration of H by applying the condition of charge-exchange equilibrium between hydrogen and oxygen atoms and ions to in-situ measurements of F-region composition and temperature from the series of Atmosphere Explorer (AE) aeronomy satellites. Progress and accomplishments on these chosen research projects are summarized below.

1. RESULTS AND ACCOMPLISHMENTS

(a). Local Time - Latitudinal (Seasonal) Variation of Hydrogen

This investigation addressed the general large-scale horizontal variability of the hydrogen concentration in the thermosphere as manifested in its dependence on local time, latitude and season. We have conducted a statistical analysis of the horizontal distribution of both the H concentration, [H], and the neutral temperature at altitudes near 300 km throughout the summer hemisphere to 68° latitude. Use was made of the comprehensive data base of measurements around the June 1974 solstice from the AE-C satellite. Our

approach has succeeded in partially decoupling effects from the various parameters cited above on the hydrogen distribution. We have demonstrated a reasonable consistency of the hydrogen diurnal behavior with the highly-selective observations of other investigators and the MSIS atmospheric model, in particular with the often-studied variation at low latitude.

We find, however, that both the magnitude and overall characteristics of the hydrogen diurnal variation to change significantly between the equator and the higher summer latitudes sampled by the AE-C spacecraft. This first-ever result is illustrated in Figure 1 for data from the 60° – 68° latitude interval; the magnitude and breadth of the daytime depletion in hydrogen are much smaller and the feature is more shifted toward local noon than that characteristic of lower latitudes. The seasonal trend is for a general decrease in thermospheric hydrogen density toward the summer pole, with the largest latitudinal gradient near predawn and the smallest during the late afternoon.

As a consequence of our general investigation, we have found several new and unanticipated features peculiar to the thermospheric hydrogen behavior.

- (i). Our analysis of the chosen AE-C data set has revealed the presence of distinct perturbations in $[H]$ that appear to be associated with several periods of large magnetic disturbance during the several months of data acquisition. Temperature increases during enhanced geomagnetic activity are theoretically expected to lower the H concentration in the thermosphere; the result should be abnormally lower densities observed with the satellite instrumentation during these particular disturbed periods. The signature of this effect has been identified in the data profiles depicting the diurnal variation – an especially strong feature is readily discernible in the high latitude data shown in Figure 1. The large decrease in derived H densities near 3–5 hrs

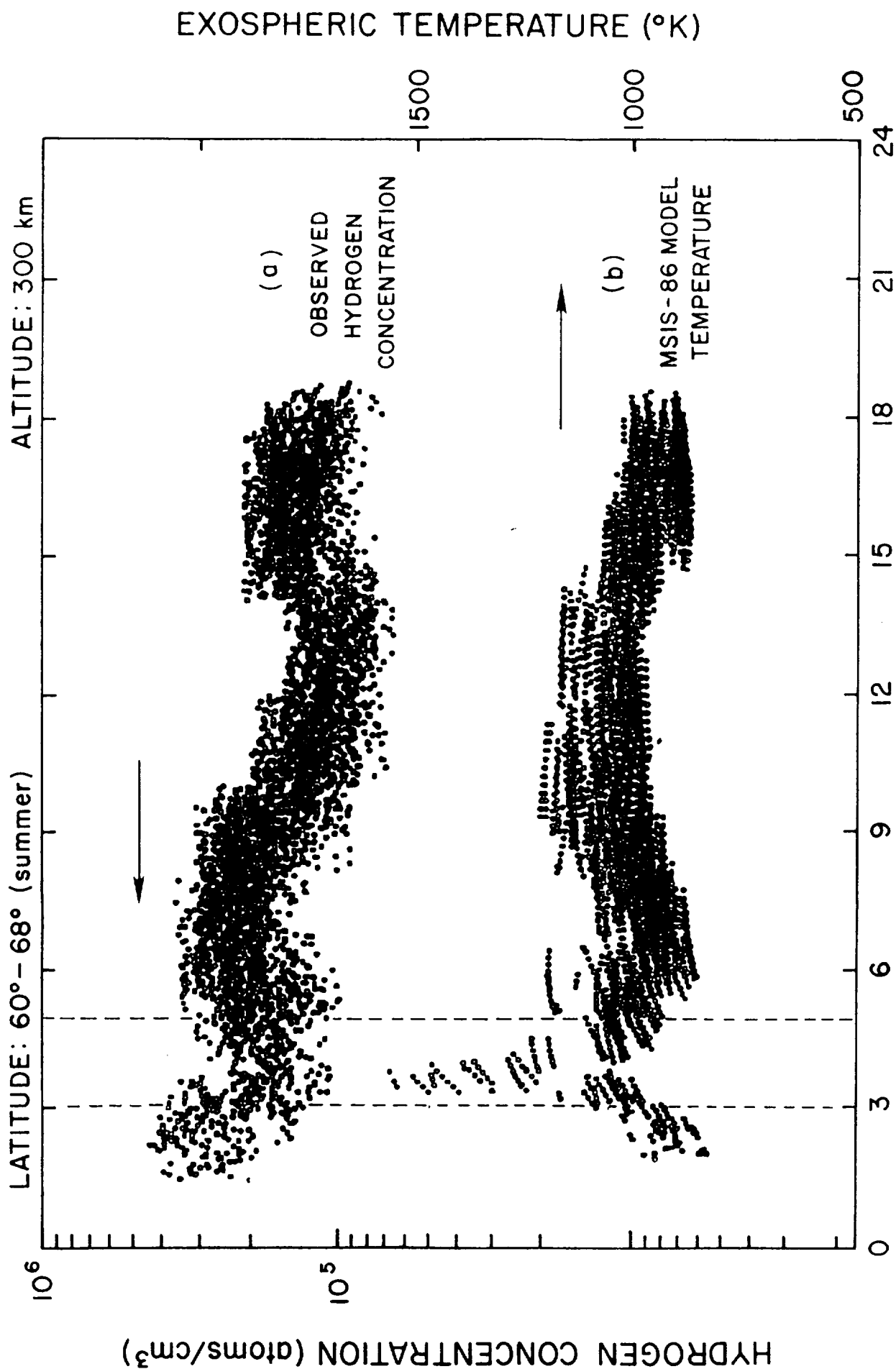


Figure 1. (a) Diurnal variation of the hydrogen density near 300 km as observed with AE-C satellite between 60 and 68 deg northern latitude during the summer of 1974.
 (b) The corresponding neutral temperature as given by the MSIS atmospheric model.

local time (Figure 1a) appears directly related to the temperature enhancements (Figure 1b) associated with the high A_p during this period as predicted by the MSIS model. Similar, but less distinct, features and inverse correlation with temperature also appear elsewhere in the data set. These observational results are believed to be the first direct evidence for the influence of magnetic activity on thermospheric hydrogen densities.

- (ii). The adopted AE-C data set includes both day and night conditions over a considerable fraction of the summer thermosphere, and thus encompasses significant variations in both the hydrogen concentration and temperature. Our statistical study of the observed horizontal distributions of these two parameters has indicated vastly different behaviors of the H density at the higher and lower prevailing temperatures. These results differ significantly from the general inverse power law expected from several exospheric theories that describe the lateral global transport of H atoms, and are strongly suggestive of non-equilibrium flow conditions.

(b). Hydrogen in the Polar Thermosphere

Our research activities also included the horizontal distribution of atomic hydrogen through both the winter and summer polar regions near solstice. We placed emphasis on ion measurements from the high-inclination AE-D satellite to infer the local abundance of neutral H near 300 km in the thermosphere. Precession of the orbit permitted observations during November–December, 1975 through the northern winter high-latitude region at local times near midnight and morning daytime. Measurements were subsequently accomplished in a dawn–dusk orbit near the southern summer pole during late January

In an earlier investigation we demonstrated a steady increase in the thermospheric H density from the summer toward the winter mid-latitudes. We also reported additional evidence for a relative reduction or depletion of [H] at the higher winter latitudes. Our current results, derived from more extensive in-situ measurements in the polar regions, are consistent with this previous conclusion. Our findings are illustrated in Figure 2 for data acquired during November and December, respectively; while there is considerable scatter in the separate data points, the general trend is suggestive of lower H concentrations in the winter polar region as compared to those at the mid-latitudes. This relative depletion in the hydrogen concentration bears an inverse correlation with the concurrent enhancement of ion temperature recorded by the onboard RPA. While the analysis and interpretation of these ion temperatures are hindered by ionospheric structure, indications are for a general increase in temperature throughout this same region of the polar thermosphere.

We further extended our analysis to investigate any possible longitudinal variability to the hydrogen concentration at high latitudes. Although handicapped by scatter and a substantial reduction in the number of statistical data points, there are clear indications of a general pattern of lower H densities and enhanced temperature in the near vicinity of the geomagnetic pole. This represents the first evidence for a UT/longitude dependence to the high latitude hydrogen distribution, a feature characteristic of other more abundant neutral species.

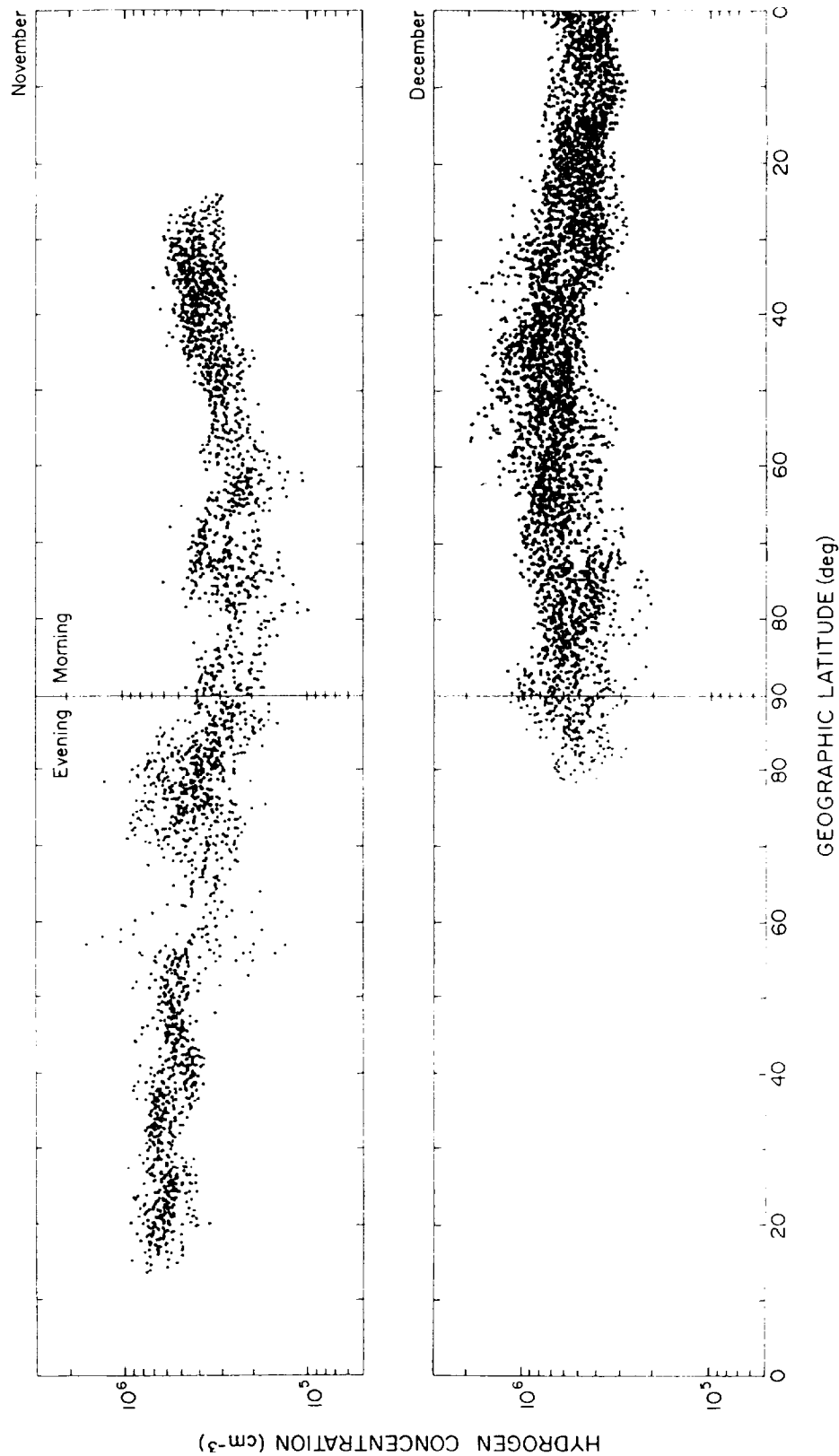


Figure 2. Hydrogen concentrations near 300 km as derived from measurements with AE-D satellite during November and December, 1975 at high winter latitudes. Local times are nominally premidnight and late morning daytime. The data give clear indications of a relative lowering of the hydrogen densities in the polar regions, relative to that at the mid-latitudes.

2. SUMMARY

Results described above were accomplished during two years of partial funding, as part of a more comprehensive program of aeronomic research in progress here with the Atmosphere Explorer data base. We have made noteworthy advances during this period in both scientific areas described, consistent with the available resources. As a summary:

A rough manuscript entitled "The variability of hydrogen with latitude and local time in the summer thermosphere from AE-C measurements" is nearing completion and describes essential findings for the investigation concerning the global behavior of thermospheric hydrogen near solstice.

As to hydrogen in the polar thermosphere, some necessary but well-defined work remains; prospects are favorable for another paper in the near future. A tentative title might be: "The behavior of thermospheric hydrogen at high winter and summer latitudes during solar minimum".

The above two papers upon completion will be submitted to the Journal of Geophysical Research, with the appropriate reference to the above NASA grant.